UCRL-WEB-201326

Linux Differences

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Preface

Scope: This Linux Differences guide summarizes the Linux-based computing resources available to LC users and explains the differences (among Linux and AIX and Tru64 UNIX) in tool and library availability, tool location (path), within-tool options and features, and operating-system features that can affect code portability and the general usefulness of local Linux computers. One section also discusses local support for POSIX threads on LC Linux machines, while another focuses on Linux-relevant environment variables. For a systematic introduction to the design goals and local enhancements built into the version of Linux that LC is itself developing (called CHAOS), see the local document called CHAOS: Linux at Livermore. (URL: http://www.llnl.gov/LCdocs/chaos)

Availability: Comparing the availability of tools and features between Linux and other LC operating systems is the prime goal of this whole manual.

Consultant: For help contact the LC customer service and support hotline at 925-422-4531 (open e-mail: lc-hotline@llnl.gov, SCF e-mail: lc-hotline@pop.llnl.gov).

Printing: The print file for this document can be found at

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OCF: http://www.llnl.gov/LCdocs/linux/linux.pdf
SCF: https://lc.llnl.gov/LCdocs/linux/linux_scf.pdf
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Introduction

This section introduces Linux, its role in providing computing resources for LC users, and the role of this document in interpreting Linux locally.

Linux Overview

GENERAL BACKGROUND.

The UNIX operating system comes in many historically related varieties. It originated at Bell Laboratories in the late 1960s, and as early as 1975 it diverged into Berkeley Software Distribution (BSD) and System V versions (with similar basic kernels for hardware interaction but somewhat different service programs). In the late 1970s, Digital Equipment Corporation developed a UNIX version called ULTRIX, enhanced and tuned to suit Digital hardware. Digital later replaced this with one of the industry's first 64-bit UNIX versions, called Tru64 (still in use on Compaq Alpha machines, such as LC's secure Furnace cluster and open LX cluster, today). After Sun and HP also offered UNIX systems, IBM decided to do the same, producing a UNIX version for their RS/6000 machines (such as the LC ASCI machines) called AIX. AIX blends into System V the BSD software features as well as POSIX 1003 standards conformance.

Meanwhile, in 1991, Helsinki University student Linus Torvalds wrote his own UNIX kernel, intended to be freely distributed for hobbiest and hacker experimentation. This was soon called Linux and its source code became available on the Internet. Richard Stallman's Free Software Foundation had already been giving away source code for a growing body of utility and service programs during the 1980s under the "GNU General Public License" (which guaranteed their free and continuing public availability). All GNU software was compatible with UNIX, but no one had actually written a free UNIX kernel to support it. Thus the happy confluence of Torvald's 1991 experiment and the on-going GNU-tools project yielded a complete open-source operating system package (or "distribution"): the Linux-based GNU system.

There are now at least half a dozen commercial providers of some variation on this open-source Linux-GNU distribution. LC's version happens to come from Red Hat, Inc.

LINUX AT LIVERMORE.

Late in 2001, LC began seriously increasing its production computing capacity for institutional (nonASCI) users with machines that run Linux. There are three reasons for this shift in emphasis toward the Linux operating system:

- COST.
  These Linux systems have much better price/performance ratios than do comparable systems running vendor-branded versions of UNIX (such as AIX).
- VENDOR INDEPENDENCE.
  Using Linux reduces LC dependence on any specific hardware/software vendor, which can allow more flexible installation and service arrangements (such as for network gear, global file systems, or job-control support).

- SOURCE ACCESS.
  Linux can be more easily modified (here, or in collaboration with others) as needed to support such special LC needs as gang scheduling of massively parallel jobs. Although vendors charge for packaging Linux, the source remains open. In fact, during 2002 LC began deploying its own locally modified version of Linux tuned for high-performance computing on many-node, Intel-chip clusters. The local version is called CHAOS, or Cluster High Availability Operating System, and it now runs on all LC Intel-chip clusters, open and secure.

This Linux Differences guide introduces the Linux resources available at LC (hardware and software). It alerts you to available tools (such as Linux compilers) and also to familiar tools not available under Linux (such as MATLAB). In some cases tool locations (paths) are also different under Linux. The text points out the dozens of UNIX utility programs (such as CP and LS) that either behave differently under Linux (same option, different result), or that have extra options only in the Linux environment. Internal operating-system differences among varieties of UNIX are noted here as well. Finally, a special section discusses support for POSIX threads and for multi-threaded programs under Linux at LC.

OTHER RELEVANT DOCUMENTATION.

For a systematic introduction to the design goals and local enhancements built into the version of Linux that LC is itself developing (named CHAOS), see the additional local document called CHAOS: Linux at Livermore. (URL: http://www.llnl.gov/LCdocs/chaos)

For a locally maintained summary of current technical tips called "Linux Basics," which emphasizes the Fortran compilers, libraries, debuggers, and other Fortran-related tools recommended for use on LC's Linux computers, see this pair of web sites:

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OCF: http://www.llnl.gov/linux/linux_basics.html
SCF: https://lc.llnl.gov/linux/linux_basics.html
```

An official online source for large amounts of Linux-specific documentation is the web site of the Linux Documentation Project at

```
http://www.ibiblio.org/mdw
```

This is not, however, a user-friendly resource for easily answering questions, but rather a place to download big sets of MAN pages, PDF reference files, or other material that a system administrator might park on a running Linux system for reuse.

Those concerned about improving the usability of Linux (in particular and UNIX in general) may want to consult the analysis at

```
http://developer.gnome.org/projects/gup/ut1_report/report_main.html
```

where Sun Microsystems staff members invoke standard usability principles and the reactions of working technical professionals to evaluate a proposed user-friendly interface for Linux, targeted at nonprogrammers.

In addition, IBM now also acknowledges Linux as an alternative to its own AIX and offers some documentation to help those (such as LC users) who have access to both varieties of UNIX and who want

to move more easily between them. IBM reference material is available online (in HTML and PDF formats) through IBM's Redbooks web site.

For a comparative survey of all IBM online manuals relevant to LC (a tiny subset of what they publish), consult LC's IBM Documentation Directory. (URL: http://www.llnl.gov/LCdocs/ibmdir) The manuals most specifically related to Linux at Livermore are:

AIX and Linux Interoperability
http://www.redbooks.ibm.com/redbooks/SG246622

which focuses on problems of cross-platform data sharing and "user management" (authentication, networking, file-system sharing, etc.), and

Linux Handbook
http://www.redbooks.ibm.com/redbooks/SG247000

which is more focused on buying and installing Linux system software on various kinds of IBM hardware (not an LC strategy).

LC's Linux Resources

LC currently has a working Linux system on OCF (with NetworX/Intel hardware), called the Intel Linux Cluster (ILX). A former open cluster with Compaq hardware (LX) has been reconfigured as a five-node experimental site. Additional large Linux clusters (MCR, ALC) are used now for special projects, not yet "generally available" to LC users.

Two additional Linux clusters are available for use on SCF (with NetworX/Intel hardware). The SCF Linux clusters, procured as Production Capacity Resource A (PCRA) and Production Capacity Resource B (PCRB), are accessed as adelie.llnl.gov and emperor.llnl.gov (with users randomly assigned to their login nodes for balance).

The table below summarizes and compares the hardware features of the LC Linux systems. Note that the start digit and the use of leading zeros *differ* between node names on the OCF Linux cluster and node names on the SCF Linux clusters.

Feature	Intel Linux Cluster (ILX)	Production Capacity Resource (Adelie)	Production Capacity Resource (Emperor)
Location:	OCF	SCF	SCF
Vendor:	Linux NetworX, SGI	Linux NetworX, SGI	Linux NetworX, SGI
Chips used:	Intel Pentium 4	Intel Pentium 4 and 3	Intel Pentium 4 and 3
Linux brand:	Red Hat 7.3	Red Hat 7.1	Red Hat 7.1
Node count:	45 nodes, all P4	128 nodes, 126 P4, 2 P3 login	80 nodes, 78 P4, 2 P3 login
CPUs per node:	2	2	2
Cluster login name:	ilx.llnl.gov	adelie.llnl.gov	emperor.llnl.gov
Login (interactive) nodes:	ilx1 to ilx4	adelie0, adelie1	emperor0, emperor1
I/O nodes:	(none)	adelie2 to adelie5	emperor2 to emperor5
Production nodes:	ilx5 to ilx45	adelie6 to adelie127	emperor6 to emperor127
Memory:	4 GB/node	2 GB/node	2 GB/node
/var/tmp local disk:	-	60 GB/node	60 GB/node
Global file system:	NetApps /nfs/tmp1	Blue Arc /nfs/tmp2	Blue Arc /nfs/tmp2
Global parallel file system:	none	none	none

Software Available

Unix Utilities

The usual hundreds of UNIX utilities are also available under Linux, but a few have different names (VI becomes VIM, for example) and quite a few have different (or differently behaving) internal options or features.

See the Within-Tool Differences (page 16) section below for an alphabetical, explanatory list of known differences in tool behavior and available options between IBM's AIX version of UNIX and Linux.

See the next subsection for a list of LC-only or localized utilities and their status on LC Linux systems. Note that Red Hat Linux 7.3, from which LLNL's CHAOS 1.2 derives, stopped supporting web browser Netscape. Consequently, all LC Linux machines that run CHAOS 1.2 or later (deployed gradually in the fall of 2003) offer Mozilla rather than Netscape as the client for web access.

See the Software Locations (page 14) section below for noteworthy differences in location (and hence in pathname) for software tools and libraries under Linux and AIX.

For running batch jobs under Linux, see the comments and references in the Batch and Resource Management (page 36) section below.

LC Utilities

Some well-known and important LC-developed (or LC-adapted) software tools are not available under Linux, or are emerging incrementally. Here is a (preliminary) list of LC-only (or LC-modified) utility programs and their current Linux/CHAOS status:

LC Tool	Under Linux?
BRLIM	YES
CHMODSTG	YES
CHGRPSTG	YES
DCECP	NO
GIVE	YES (also across machines)
GUIDE	NO
HTAR	YES
JJ	NO
JS	NO
JU	NO
KINIT	YES
LFT	YES
LIB76	YES
LSTORAGE	YES
MATLAB	NO
MAXJOBS	NO
MOLE	YES
MOZILLA	YES
NETSCAPE	NO (use MOZILLA)
NFT	YES
PCSUSAGE	YES
PDSH	YES
PHIST	YES
QUOTA	YES
SCANCEL	YES
SFTP	YES
SINFO	YES
SPJSTAT	NO (use SQUEUE instead)
SQUEUE	YES
SRUN	YES
SUPER	YES
TAKE	YES (also across machines)
UINFO	YES
XSSH	YES

Compilers

Besides the usual CCC (Linux for CC) and C++ compilers, the OCF Linux machines also offer the GNU-project compilers GCC, G++, and G77, all in /usr/bin.

On the SCF Linux clusters Aledie and Emperor, LC also offers the corresponding Intel compilers ICC and IFC as well. Because of subtle system, library, and compiler differences, you should recompile all codes before running them under Linux, and you should use the Intel compilers whenever you can.

AVAILABILITY.
On the SCF PCR Linux clusters (Adelie and Emperor), the available compilers on the login nodes include:

Compiler Name	**Directly Invoked By**	**Invoked By MPI Script(*)**
Intel Fortran	ifc	mpiifc
Intel C++	icc	mpiicc
PGI C	pgcc	mpipgcc
PGI C++	pgCC	mpipgCC
PGI HPF	pghpf	mpipghpf
PGI F90	pgf90	mpipgf90
PGI F77	pgf77	mpipgf77
KCC++	/usr/local/KAI/KCC_BASE/bin/KCC	
GCC	see below	mpicc
G77	see below	(none)

(*)MPI scripts reside in /usr/lib/mpi/bin.

Because of compatibility problems between GCC version 3.0.4 and the TotalView debugger (and other applications), that latest compiler version is not the GCC default on LC Linux machines. Many alternatives are available, and you can use these execute lines to invoke the specific GNU-compiler version and variety that best suits your needs:

```
Link in             Invokes this
/usr/local/bin      underlying compiler version
--------------      ---------------------------
g++-2.95.3          /usr/local/tools/gnu/gcc/2.95.3/bin/g++
g++-3.0.4           /usr/local/tools/gnu/gcc/3.0.4/bin/g++
g77-2.95.3          /usr/local/tools/gnu/gcc/2.95.3/bin/g77
g77-3.0.4           /usr/local/tools/gnu/gcc/3.0.4/bin/g77
gcc-2.95.3          /usr/local/tools/gnu/gcc/2.95.3/bin/gcc
gcc-3.0.4           /usr/local/tools/gnu/gcc/3.0.4/bin/gcc
```

OTHER DIFFERENCES.

(1) LD_LIBRARY_PATH
Invoking the setup script for the Intel compilers (ICC, IFC) on the SCF Linux clusters, namely

```
source /opt/intel/compiler50/ia32/bin/iccvars.sh
```

sets the environment variable LD_LIBRARY_PATH to specific Intel libraries. If you alternate between using ICC and the GNU compiler GCC, you should unset this variable by hand each time you use GCC.

(2) NODE INCOMPATIBILITIES

The two login (interactive) nodes on the Emperor and Adelie SCF Linux clusters use Pentium 3 rather than Pentium 4 Intel chips. If you use the ICC or IFC compilers to generate code exclusively for the Pentium 4 instruction set (with options -xW -tpp7), the result will *not* run directly on the Pentium 3 login nodes. Compiling instead with option combination -axW produces code that will run on both Pentium 3 and Pentium 4 chips, but with a somewhat larger executable size.

(3) VECTORIZATION (INTEL)

Intel Pentium 4 CPUs have 8 128-bit registers that are used as vector registers by the SSE2 (Streaming SIMD Extensions 2) instructions. When code is vectorized, these registers are not just used for floating-point calculations but packed with multiple values prior to an add or multiply step. This packing leaves no room for extra precision in vectorized code. Hence, roundoff differences can and do occur between floating-point results produced from vectorized and from nonvectorized executables built from the same source code. Only you can decide if the precision of Intel vectorized code is sufficient for your needs.

(4) VECTORIZATION (PGI)

The Linux PGI compilers do *not* use the SSE2 vectorization features described above. If your code vectorizes well, therefore, using the Intel compilers can provide significant performance gains over using the PGI compilers. For nonvectorized code, the performance results are usually very much the same.

(5) NONSTANDARD OUTPUT

Compiling with the ICC or IFC compilers without invoking the -mp ("maintain precision") option can produce assembler code that does not conform to IEEE 754 or ANSI C standards (and this nonconformance may alter your floating-point results).

(6) KCC/GCC SLOW DOWN

On LC Linux systems, KCC uses only GCC as its back-end compiler, not PGCC or ICC. Tests at LC suggest that GCC-compiled scientific codes generally run at one-third to one-half the speed of the same code compiled with ICC.

Affinity Program

Compaq (at www.compaq.com/linux) advertises a package of software (an "affinity program") to facilitate switching between Tru64 and Linux versions of UNIX on Compaq machines. LC has NOT purchased and does NOT provide this conversion package on its Linux computers.

NETMON Relevance

LC's locally developed NETMON (URL: http://www.llnl.gov/LCdocs/netmon) web sites (open and secure) list and plot network traffic for several popular "services" (such as FTP and SSH) between pairs of LC network nodes. Storage and many AIX and graphics nodes are covered by NETMON monitoring. However, *no* Linux/CHAOS node in any cluster on either OCF or SCF is currently among the set between which NETMON monitors traffic.

Software Locations

Software available under Linux is sometimes located differently (along a different pathname) than under other versions of UNIX on LC machines. As with availability, Linux software location is an evolving story. Currently important Linux directories include:

/dfs	is *not* mounted on any LC Linux node (but is on all AIX and Tru64 nodes).
/usr/bin	holds the standard Red Hat distribution tools (such as MAKE and NROFF) as well as their GNU-project counterparts (such as GMAKE and GNROFF), along with all of the Linux compilers. WARNING: Starting in 2002, IBM keeps its AIX compilers in /usr/local/bin rather than in /usr/bin (where they reside under Linux), a difference to remember if you invoke compilers with their full pathname (hence, this practice is not recommended).
/usr/local/bin	does not duplicate /usr/local elsewhere because of license restrictions on some software tools. This is the Linux home for TOTALVIEW, MOLE, and YORICK, for example.
/usr/gapps	replaces /usr/apps as the place for user-developed shared software on LC's Linux computers.
/usr/give	is a file system mounted across OCF (only) "production machines" to hold the files that one user GIVEs to another. In general, this enables across-machine GIVEs on OCF (between Blue and GPS, for example). However, although /usr/give is mounted on ILX, the local GIVE and TAKE clients look only in /usr/local/give for files to exchange. So you *cannot* (yet) perform across-machine GIVEs (or TAKEs) to or from open Linux machines.
/usr/tmp	is a small work directory on each node. You should use /nfs/tmp1 or another global file system to hold your large working files or output.
/usr/local/hdf5	contains the available HDF5 I/O library and helper programs. Under Linux, the latest library version is hdf5-1.4.2 and there is no Fortran counterpart to the C and C++ libraries. HDF5 tools (such as H5DUMP) reside in another subdirectory several layers from the top. See the separate I/O Guide for LC (URL: http://www.llnl.gov/LCdocs/ioguide) for a comparison of HDF5 features under AIX and Linux.
/usr/local/lib	contains much less than under AIX or Tru64, but is still the place for the vendor-independent precompiled mathematics and other library files that are available (such as PMATH and SPRNG). See also /usr/local/intel/mkl.

/usr/local/intel/mkl

(on Intel Linux machines only, such as ILX, Adelie, or Emperor) contains Intel's own Math Kernel Library (MKL), a good source for BLAS and LAPACK routines in the Linux environment. The relevant subdirectories are:
/lib/32 (contains the library files),
/include (contains the include files),
/doc (contains vendor documentation files).

Within-Tool Differences

Some software tools or utility programs are available under both Linux and other versions of UNIX (such as IBM's AIX), but the syntax or function of one or more internal options differs by operating-system version. Sometimes the Linux version of a tool offers more options than AIX supports. This section lists the utility programs that have such within-tool (option) differences, and it briefly explains the difference in syntax or function for each option where they diverge. The first subsection below covers the most widely used UNIX tools. The second covers the less common or more specialized tools, tools whose intricate differences defy brief summary here, or tools for root users or system administrators only. (Each set is in alphabetical order.)

Often-Used Tools

These popular software tools differ in their Linux implementation from their implementation under other versions of UNIX (especially IBM's AIX) in the ways summarized below. See the next subsection for more obscure or specialized tools.

at — runs commands at a later time.
Same Option, Different Role:
-c
AIX: runs the job with csh.
Linux: cats the job to standard output.
Options in Linux ONLY:
-d.....is an alias for ATRM.
-v.....shows the time the job will run.
-V.....prints the version number.

banner — outputs large character strings.
Same Option, Different Role: None.
Options in Linux ONLY:
-w nnn.....uses output width of nnn characters (instead of 80).

cal — displays a calendar.
Same Option, Different Role: None.
Options in Linux ONLY:
-m.....makes Monday the first day of the week.
-j.....displays Julian dates (numbered from Jan. 1).
-y.....displays a calendar for the current year.

chgrp — changes a file's group.
Same Option, Different Role: None.
Options in Linux ONLY:
-c,-changes.....like verbose, but reports only changes.
--reference=rfile.....assigns the group to match rfile's.
-v,--verbose.....reports on every file processed.

chmod — changes a file's permissions.
Same Option, Different Role: None.
Options in Linux ONLY:
-c,-changes.....like verbose, but reports only changes.
--reference=rfile.....assigns the permissions to match rfile's.
-v,--verbose.....reports on every file processed.

chown — changes a file's ownership.
Same Option, Different Role: None.
Options in Linux ONLY:
-c,-changes.....like verbose, but reports only changes.
--dereference.....acts on a symbolic link's referent, not on the link.
--reference=rfile.....assigns the ownership to match rfile's.
-v,--verbose.....reports on every file processed.

compress — compresses a file.
Same Option, Different Role: None.
Options in Linux ONLY:
-r.....recursively compresses every file in a specified directory.

cp — copies one file or directory to another.
Same Option, Different Role: None.
Options in Linux ONLY:
-a,--archive.....same as -dpR.
-b,--backup.....makes a backup before removal.
-d,--no-dereference.....preserves links but removes existing destinations.
--help.....lists options.
-l,--link.....links files instead of copying (see -s).
-P,--parents.....appends source path to a directory.
--sparse=when.....controls creation of sparse files.
-s,--symbolic-link.....makes symbolic links instead of copying.
-S,--suffix=sss.....overrides the usual backup suffix.
-u,--update.....copies only when source is newer than sink.
-v,--verbose.....explains what is happening.
-V,--version-control=vvv.....overrides unual version control.
-x,--one-file-system.....stays on current file system.
--version.....outputs version info and ends.

cut — writes selected parts from each line of a file.
Same Option, Different Role: None.
Options in Linux ONLY:
--help.....lists options.
--output-delimiter=sss.....uses string sss to delimit output.
--version.....outputs version info and ends.

date — displays current date and time.
Same Option, Different Role: None.
Options in Linux ONLY:
-d,--date=string.....displays date for string, not now.
-f,-file=dfile.....same as -d for every line in dfile.
-I,--iso8601.....outputs an ISO-8601 compliant date and time.
-r,--reference=rfile.....displays when rfile was last modified.
-R,--rfc822.....outputs an RFC-822 compliant date and time.
--help.....displays brief help.
--version.....displays version info and ends.

df — ("disk free") reports free space on mounted file systems.
Same Option, Different Role:
-k
AIX: reports in 1-kbyte blocks (default is 512-byte blocks).
Linux: unneeded, 1-kbyte blocks are the default.

du — summarizes your disk usage.
Same Option, Different Role: None.
Options in Linux ONLY:
-b,--bytes.....prints amount used in bytes.
-c,--total.....prints a grand total.
-D,--dereference.....reports on symbolic links instead of their referents.
--exclude=pat.....excludes files that match pat.
-h,--human-readable.....prints sizes with units (e.g., 2G).
-H,--si.....same as -h but in powers of 1000, not 1024.
-L,--dereference.....dereferences all symbolic links.
-m,--megabytes.....uses a block size of 1048576.
--max-depth=n.....reports only files n or fewer levels below DU.
-S,--separate-dirs.....excludes the size of subdirectories.
-X fff,--exclude-from=fff.....excludes files that match any pattern in fff.
--help.....displays brief help.
--version.....displays version info and ends.

echo — writes character strings to standard output.
Same Option, Different Role: None.
Options in Linux ONLY:
-n.....omits the trailing newline character.

env — displays or sets environment variables.
Same Option, Different Role: None.
Options in Linux ONLY:
-u,--unset=name.....removes the named variable from the environment.

expand — expands tabs to spaces in output.
Same Option, Different Role: None.
Options in Linux ONLY:
-i,--initial.....converts tabs only if preceded by white space.
-t,--tabs=nnn.....converts tabs to nnn spaces, not 8 spaces.

ftp — transfers files to or from a remote host.
Same Option, Different Role:
AIX: site umask|chmod.
Linux: chmod.....changes file permissions.
Linux: umask.....sets remote default umask.
parallel
AIX: transfers with AIX *target* are automatically parallel.
Linux: transfers with Linux *target* need PARALLEL toggle.
Options in Linux ONLY:
-e.....disables command editing and history.
-p.....uses passive mode (if server supports PASV).

head — displays the first few lines of a file.
Same Option, Different Role: None.
Options in Linux ONLY:
--help.....displays an option list.
-q,--quiet.....never prints headers giving file names.
-v,--verbose.....always prints headers giving file names.
--version.....outputs version info and ends.

join — joins the data fields of two files.
Same Option, Different Role: None
Options in Linux ONLY:
--help.....displays brief help message.
--version.....outputs version info and ends.

kill — signals a running process to stop.
Same Option, Different Role: None
Options in Linux ONLY:
-p.....prints process ID but does not kill.

ln — links files or directories.

Same Option, Different Role: None

Options in Linux ONLY:

-b,--backup.....makes backup of each destination file.
-n,--no-dereference.....treats symlink directory targets as normal files.
-i,--interactive....prompts whether to remove destinations.
-S,--suffix.....overrides the usual backup suffix.
-v,--verbose.....prints name of each file before linking.
-V,--version-control.....overrides usual version control.
--help.....displays the LN man pages.
--version.....outputs version info and ends.

ls — lists file in a directory.

Same Option, Different Role: None.

Options in Linux ONLY:

--block-size=nnn.....uses nnn-byte blocks.
-B,--ignore-backups.....skips implied entries ending with tilde.
--color=never|always|auto.....specifies when color distinguishes file types.
-D,--dired.....outputs in Emacs dired mode.
--format=across|commas|long|vertical.....same as -x, -m, -l, -C.
--full-time.....lists full date and full time.
-G,--no-group.....supresses group information.
-h,--human-readable.....prints sizes with units (e.g., 2G).
-H,--si.....same as -h but uses powers of 1000, not 1024.
--indicator=none|classify|file-type.....appends specified indicator.
-I,--ignore=pattern.....skips entries matching pattern.
-k,--kilobytes.....same as --block-size=1024.
-Q,--quote-name.....encloses entry names in double quotes.
--quoting-style=literal|shell-always|c|escape....specifies quoting style.
-S.....sorts files by size.
--sort=extension|none|size|time|version|status|use....specifies sorting.
--time=access|status|use.....changes the time displayed.
-T,--tabsize=cols.....sets tab stops at cols instead of 8.
-U.....lists entries unsorted, in directory order.
-v.....sorts files by version.
-w,--width=cols.....sets screen width to cols.
-X.....sorts alphabetically by file extension.
--help.....shows MAN pages for ls.
--version.....shows version info and ends.

mail — sends and receives e-mail.

Same Option, Different Role: None.

Options in Linux ONLY:

-b.....sends blind carbon copies to a comma-separated list.
-I.....runs interactively even when input is not a terminal.

man — displays "manual" pages online.

Same Option, Different Role:

-t

AIX: formats the output with TROFF.

Linux: formats the output with /usr/bin/groff -Tps -mandoc.

Options in Linux ONLY:

-a.....displays ALL man pages that match request.

-C cfile.....specifies a configuration file other than /etc/man.config.

-d.....shows debug info instead of man pages.

-D.....shows debug info AND man pages.

-F,--preformat.....formats output but does not display.

-h.....prints a one-line help message.

-K.....searchs ALL man pages for string.

-m mmm.....searches an alternate set of man pages specified by mmm.

-p ppp.....specifies which preprocessors to run if their code appears in ppp: eqn(e), grap(g), pic(p), tbl(t), vgrind(v), refer(r).

-P pager.....specifies a pager instead of /usr/bin/less-is.

-w,--path.....displays the location of man pages instead of their content.

-W.....same as -w but output one per line.

more — shows text one screen at a time.

Same Option, Different Role:

-l

AIX: pauses display after each page break.

Linux: pauses display after each form feed.

-p

AIX: executes a specified subcommand.

Linux: avoids scroll, clears screen and shows text.

Options in Linux ONLY:

-f.....counts logical, not screen, lines (no folding).

+num.....starts display as line num.

+/.....searches for a specified string.

mv — moves one file or directory to another.

Same Option, Different Role: None.

Options in Linux ONLY:

-b,--backup.....makes a backup before removal.

-S,--suffix=sss.....overrides the usual backup suffix.

-u,--update.....moves only when source is newer than sink.

-v,--verbose.....explains what is happening.

-V,--version-control=vvv.....overrides unual version control.

pr — writes a file to standard output.

Same Option, Different Role: None.

Options in Linux ONLY:

-c,--show-control-chars.....uses hat (up-arrow) notation.
-J,--join-lines.....merges full lines, disables -W.
-l,--length=ppp.....sets page length to ppp lines.
-N,--first-line-number=nnn.....counts from nnn as first line, first page.
-S[sss],--sep-string=sss.....separates columns using string sss.
-v,--show-nonprinting.....uses octal backslash notation.

ps — shows current status of processes.

Same Option, Different Role:

-c
AIX: reports only on specified processes classes.
Linux: changes scheduler info for -l.
-s
AIX: displays size of kernel stack.
Linux: displays signal format.
-v
AIX: displays 8 special fields.
Linux: displays virtual memory format.

Options in Linux ONLY:

-A.....shows all processes.
-C.....selects by command name.
--cols,--columns.....sets screen width.
--cumulative.....includes some dead child processes.
-g,--group,--Group.....selects by group.
-H,--forest.....shows process hierarchy.
-h,--no-header.....omits header lines.
--headers.....repeats header lines.
--help.....prints help message.
--info.....prints debugging information.
-j.....gives extra job-control details.
--lines,--rows.....sets screen height.
--nul,--null.....outputs unjustified.
-o,-O.....allows user-defined output format.
-r.....reports running processes only.
--sort.....specifies sorting order.
--User.....selects by real user name.
-V,--version.....prints version number.
--width.....same as --cols.
-y.....does not show flags.
--zero.....same as --null.

rm — removes files or directories.
Same Option, Different Role: None.
Options in Linux ONLY:
-r.....recursive removal, always works for Linux, fails when path exceeds PATH_MAX under AIX.

sort — sorts files in specified ways.
Same Option, Different Role: None.
Options in Linux ONLY:
-g.....compares by numerical value (implies -b).
-M.....compares by date (implies -b).
-s.....stabilizes a sort by disabling last resort comparison.

split — divides a file into pieces.
Same Option, Different Role: None.
Options in Linux ONLY:
-C,--line-bytes=sss.....puts at most sss bytes of lines per output file.

sum — displays checksum and block count of a file.
Same Option, Different Role: None.
Options in Linux ONLY:
-s,--sysv.....uses 512-byte blocks (System V algorithm).

tail — displays the last few lines of a file.
Same Option, Different Role: None.
Options in Linux ONLY:
--help.....displays an option list.
-q,--quiet.....never prints headers giving file names.
--retry.....keeps trying to open an inaccessible file.
-v,--verbose.....always prints headers giving file names.
--version.....outputs version info and ends.

tar — makes and manages file archives.

Same Option, Different Role:

-F
AIX: checks file type before archiving.
Linux: runs script at end of each tape.

-L
AIX: writes specified directories NOT recursively.
Linux: changes tape after writing N*1024 bytes.

-l
AIX: reports errors if links not all archived.
Linux: stays within the local file system.

-N
AIX: allows large block clusters (default: 20).
Linux: only stores files newer than DATE (--newer).

-s
AIX: tries to create a symbolic link.
Linux: sorts list of names to extract (--same-order).

-S
AIX: specifies using 512-kb blocks/volume.
Linux: handles sparse file efficiently (--sparse).

Options in Linux ONLY:

-A,--concatenate.....appends files to archive.
--atime-preserve.....keeps access times on dumped files.
--block-compress.....blocks compressed output for tape.
--checkpoint.....prints dir names while reading archive.
-d,--diff,--compare.....finds archive/file-system differences.
--delete.....deletes from an archive.
--exclude fff.....omits named file fff.
--force-local.....always keeps archive on local disk.
-G,--incremental.....invokes old GNU-format backup.
-g,listed-incremental.....invokes new GNU-format backup.
--ignore-failed-read.....ignores unreadable files.
-k,--keep-old-files.....does NOT overwrite existing files from acrhive.
-K,--starting-file fff.....starts at fff in archive.
-M,--multi-volume.....signals a multi-volume archive.
-O,--to-stdout.....extracts files to standard output.
-P,--absolute-paths.....leaves leading /s on file names.
-R,--record-number.....shows each within-archive record number.
--remove-files.....removes files after adding to archive.
--same-owner.....keeps ownership on extracted files.
-T,--files-from fff.....gets file names from file fff.
--use-compress-program ppp.....filters archive through ppp.
-V,--label nnn.....calls archive volume nnn.
--version.....prints version information.
-W,--verify.....trys to verify the archive after writing it.
-X,--exlude-from fff.....excludes all files listed in fff.

-Z,--compress,--uncompress.....filters archive through COMPRESS.
-z,--gzip,--unzip.....filters archive through GZIP.

telnet — connects interactively to a remote host.
Same Option, Different Role:
-e
AIX: specifies a terminal type (vt100, 3270).
Linux: specifies an escape character.
Options in Linux ONLY:
-8.....specifies 8-bit data path on input (see -L).
-a.....trys automatic login with current user name.
-b alias.....binds local socket to aliased address.
-c.....disables reading the user's .telnetrc file.
-E.....eliminates any escape character.
-K.....specifies no automatic login to remote host.
-L.....specifies 8-bit data path on output (see -8).
-r.....specifies user interface like RLOGIN.
-S.....sets the IP type-of-service option.
-X atype.....disables atype authentication.
-x.....enables encryption of data stream if possible.

time — prints a command's execution time.
Same Option, Different Role: None.
Options in Linux ONLY:
TIME is a system call, not a command, under Linux.

tr — translates characters.
Same Option, Different Role: None.
Options in Linux ONLY:
-t.....first truncates string1 to length of string2.

type — describes a specified command.
Same Option, Different Role: None.
Options in Linux ONLY:
--all ccc.....prints all places that contain ccc.
--path ccc.....prints the name of disk file that ccc executes.
--type ccc.....prints one of: alias, keyword, function, builtin, file.

uname — reports system name and details.
Same Option, Different Role:
-a
AIX: reports same as -mnrsv.
Linux: reports all information.
Options in Linux ONLY:
--help.....displays a help message.
--version.....displays version info and ends.

uncompress — uncompresses a file.
Same Option, Different Role: None.
Options in Linux ONLY:
-r.....recursively uncompresses every file in a specified directory.

uniq — deletes duplicated lines in a file.
Same Option, Different Role: None.
Options in Linux ONLY:
-D,--all-repeated.....prints all duplicate lines.
-i,--ignore-case.....ignores case differences when comparing.
-w,--check-chars=nnn.....compares no more than nnn characters/line.

userinfo — opens a separate window and reports the full name, office telephone, and default shell of the user who runs it.
NOTE: LC's local tool UINFO avoids the separate window and reports the same information plus numerical UID, home directory, group memberships, and bank memberships (for any specified user).

vi|vim — edits files with full-screen display.
Same Option, Different Role:
AIX: executed by vi [options][file]
Linux: executed by vim [options][file]
Options in Linux ONLY:
[many and complex]

wc — counts words, lines, bytes in a file.
Same Option, Different Role: None.
Options in Linux ONLY:
-L,--max-line-length.....reports length of the longest line.

which — locates files under C shell.
Same Option, Different Role: None.
Options in Linux ONLY:
-a,--all.....prints all matching files, not just first.
-i,--read-alias.....reads aliases from stdin, reports matches on stdout.
--show-dot.....prints ./match, not full path.
--show-tilde.....outputs tilde when directory matches HOME.
--skip-alias.....ignores --read-alias.
--skip-dot.....ignores directories that start with dot.
--skip-tilde.....ingores directories that start with tilde.
--tty-only.....stops processing if not on tty.
--version.....prints version info and ends.

who	reports currently logged-in users. Same Option, Different Role: -l AIX: lists only LOGIN processes. Linux: lists originating machine for each user. Options in Linux ONLY: --help.....displays a help message. --version.....displays version info and ends.

Specialized Tools

The software tools listed here have known internal (option) differences in implementation between Linux and other versions of UNIX, but those differences are very specialized, too complex to usefully summarize here, or relevant only to root users or system administators. If you know these tools elsewhere and plan to use them under Linux, consult one of the online files below to see how IBM explains their complex differences under AIX and Linux:

http://ftp.software.ibm.com/aix/freeSoftware/aixtools/docs/cmdsdiff_a_n.html
http://ftp.software.ibm.com/aix/freeSoftware/aixtools/docs/cmdsdiff_o_z.html

See the previous subsection for summarized, option-level differences in the most common, often-used UNIX software tools.

```
ac
ar
atq
atrm
awk

bc
bsh

chroot
cmp
cpoi
crontab
csplit
ctags
cu

dd
diff
diff3

ed

file
find
fortune
fuser

gprof
grep

halt

id
indent
init
install
ipcs

jobs

killall
```

```
ksh

last
lastcomm
lex
logger
look


make
man
mknod
mount
mt

passwd
patch

rdist
reboot
red
restore
rmt
rsh

sa
sdiff
sed
sh
shutdown
strings
stty

telinit
test

ulimit
units

vmstat

w
```

```
xargs
yacc
```

Operating System Differences

Operating system kernels, including UNIX, have many features to manage a computer's hardware on behalf of user (application) software. Most kernel features are shared among most varieties of modern UNIX, but a few are not. Relevant here are the specific features that Linux lacks but that other UNIX varieties used at LC, such as AIX or Tru64, usually possess.

This table, based on a comparative analysis of Linux kernel features published by Cesar de Silva in June, 2001, for the most recent Linux version at that time, shows which widely shared features Linux lacks.

Kernel Feature	Linux	AIX	Tru64
Dynamic Processor Resilience: isolates faulty CPUs, continues without them.	NO	YES	YES
Dynamic Memory Resilience: isolates faulty memory areas with single-bit errors.	NO	YES	YES
Dynamic Page Sizing: uses variable page sizes for I/O when file sizes vary.	NO	NO	YES
Access Control List (ACL): assigns each file and directory an access list to control who has what type of access.	NO	YES	YES
CacheFS: improves efficiency of NFS-mounted disk access by caching.	NO	YES	NO
IPsec: provides standard security for network or packet layer during communications.	NO	YES	YES

POSIX Threads Under Linux

Besides allowing execution of multiple processes at the same time, Linux (as with most other versions of UNIX) now supports multiple threads (independent flows of control) within a single process (all sharing the same process resources, such as address space and files). Communication among threads is much easier that among separate processes, but thread synchronization to avoid trouble demands careful planning.

The Red Hat Linux (CHAOS) systems at LC support standard POSIX 1003.lc threads (usually called "pthreads"). While originally used with a native batch system (RMS) that was *not* thread aware, CHAOS now supports a locally designed, thread-aware resource manager called SLURM (details below).

GENERAL BACKGROUND.
You should consult the POSIX Threads Overview (For LC) (URL: http://www.llnl.gov/LCdocs/pthreads), a locally maintained introductory guide to pthreads use here, if you need primarily:

- A conceptual review of process/thread relationships,
- A summary of general pthreads benefits and pitfalls, with special attention to five different thread-synchronization alternatives (and cross references to code examples elsewhere), or
- A comparison of different vendor implementations of pthreads on LC machines (including comparative system defaults for AIX and Linux).

LINUX THREADS TUTORIAL.
You should consult the POSIX Threads Tutorial (URL: http://www.math.arizona.edu/swig/pthreads/threads.html) by Mark Hays (at

```
http://www.math.arizona.edu/swig/pthreads/threads.html)
```

if you need primarily a tour of the most common pthreads issues, routines, and design techniquues with C-language examples that have been tested exclusively on Linux systems (using the glibc compiler and the LinuxThreads library). The emphasis here is on general pthreads topics that happen to be shown by Linux-tested cases, *not* on the specific Linux resources that support pthreads (or on how pthreads under Linux differ from pthreads elsewhere).

EXCLUSIVE LINUX/THREADS ISSUES.
You should consult The LinuxThreads Library (URL: http://pauillac.inria.fr/~xleroy/linuxthreads) by Xavier LeRoy and colleagues (at http://pauillac.inria.fr/~xleroy/linuxthreads) if you need primarily:

- Help with the glibc (GNU) compiler and links to background on compiling pthreads specifically under Linux.
- Help with the gdb thread-aware debugger and links to background on debugging pthreads codes under Linux.
- Information on (getting or) using the LinuxThreads library that is already on all LC Red Hat Linux systems, including a frequently asked questions file and links to several emulators that run on top of LinuxThreads. LinuxThreads implements standard POSIX threads for Linux.

SLURM.

The Simple Linux Utility for Resource Management (SLURM) has replaced RMS as the low-level job-control scheme on all LC Linux clusters. The SLURM tool that allocates resources and launches parallel jobs is called SRUN. SRUN now offers several options intended to help you properly assign compute resources to pthhreads applications. SRUN's -c (lowercase) option lets you specify multiple CPUs per task, while -T (uppercase) lets you specify the number of threads per job. See the SRUN sections of the SLURM Reference Manual (URL: http://www.llnl.gov/LCdocs/slurm) for details on the complex ways in which SRUN options (these two and others) can interact.

Environment Variables

You should set these environment variables (with SETENV for the C shell or EXPORT for the SH or KSH shells) when you run parallel batch jobs on LC Linux systems. See the POE User Guide (URL: http://www.llnl.gov/LCdocs/poe) for corresponding IBM environment variables relevant to MPI jobs. (All those that mention LIBELAN support your program's use of Quadrics Elan, a library of low-level functions that provides a message-passing interface for the local network of Linux nodes.) See the "Environment Variables for Batch Jobs" section of the DPCS Reference Manual (URL: http://www.llnl.gov/LCdocs/dpcs) for a helpful set of environment variables (all called PSUB_*name*) that DPCS supports in *every* DPCS-managed production environment to provide a uniform context for batch runs among AIX and Linux systems. NOTE: all Elan-related environment variables have no role on the open-network ILX cluster, because it has no Quadrics fast interconnect.

The CHAOS Simple Linux Utility for Resource Management (SLURM) uses its own additional environment variables (all with names that begin with "SLURM_") to store resource-allocation values for the jobs that SLURM manages. See the "Environment Variables" section of the SLURM Reference Manual (URL: http://www.llnl.gov/LCdocs/slurm) for an explanatory list.

LIBELAN_GALLOC_EBASE

(default value: 0xb0000000) resizes the Elan global memory heap for MPI collective operations. EBASE is a pointer to a base virtual address in Elan memory to be used for the global heap. (Set this variable and the next two if you use MPI collectives, such as REDUCE, GATHER, SCATTER, or their ALL versions, with more than about 100 processes.)

LIBELAN_GALLOC_MBASE

(default value: 0xb0000000) resizes the Elan global memory heap for MPI collective operations. MBASE is a pointer to the main memory base in Elan memory to be used for the global heap.

LIBELAN_GALLOC_SIZE

(default value: 16777216) resizes the Elan global memory heap for MPI collective operations. SIZE is the size in bytes of the Elan global heap.

LIBELAN_WAITTYPE

(suggested value: POLL) specifies how a blocking MPI process will share computing resources (comparable to MP_WAIT_MODE under POE on IBM machines). Possible values are:

POLL	(default) has the receiving thread actively poll for incoming messages. Use this choice for all MPI jobs on clusters that have a Quadrics interconnect.
SLEEP	has the receiving thread sleep and thus remove itself from the active dispatching queue.

YIELD — has the receiving thread stay in the queue but yield the processor if it has no work to do.

MALLOC_TRIM_THRESHOLD

(suggested value: -1) see the next item for joint use.

MALLOC_MMAP_MAX

(suggested value: 0) when combined, MALLOC_TRIM_THRESHOLD and MALLOC_MMAP_MAX force MALLOC to use SBRK() rather than MMAP() to allocate memory. This improves performance, but it may reduce the total amount of memory available to your user processes (to no more than 1 Gbyte/process).

MPI_USE_LIBELAN

toggles the Elan library optimizations. Possible values and their roles are:

1 — (default) enables the Elan library optimizations.

0 — disables the Elan library optimizations. Use this only for debugging, if you suspect problems with the Elan libraries themselves.

OMP_NUM_THREADS

controls the number of threads spawned by Intel's Math Kernel Library (MKL) routines when you invoke this threaded library on any of LC's Intel Linux machines (such as ILX, Adelie, or Emperor). By default, MKL sets the number of threads equal to the number of processors.

Batch and Resource Management Systems

LC's Distributed Production Control System (DPCS) is being modified to provide enhanced support for parallel jobs on local Linux clusters. Among the relevant enhancements now underway are:

TBS	(Trivial Batch System) replaces NQS as the underlying batch system for managing queued and competing batch jobs on Linux systems without a switch.
SLURM	(Simple Linux Utility for Resource Management) is a collaborative project between LLNL and vendor Linux NetworX to manage "compute resources" (available nodes, time to run on them, interconnect access) in the face of conflicting requests for those resources in Linux environments. SLURM replaces RMS on Linux systems with a switch.

More details (and links) will appear here as these and related DPCS refinements for Linux gradually emerge on LC machines. See also the SLURM section of the local manual called and the separate SLURM Reference Manual. (URL: http://www.llnl.gov/LCdocs/slurm)

Disclaimer

Keyword Index

To see an alphabetical list of keywords for this document, consult the next section (page 39).

Keyword	Description
entire	This entire document.
title	The name of this document.
scope	Topics covered in this document.
availability	Applies to Linux at LC.
who	Who to contact for assistance.
introduction	Linux at LC introduced.
linux-overview	Linux background, role at LC.
linux-resources	Comparison of LC Linux machines.
software	Software present, absent under Linux.
unix-utilities	Standard UNIX tools under Linux.
lc-utilities	LC-only or localized tools.
compilers	Compilers on LC Linux machines.
affinity	Compaq Linux affinity program.
netmon	NETMON's relevance to Linux nodes.
locations	Software paths under Linux.
tool-options	Within-tool option, feature differences.
often-used-tools	Within-tool differences (common).
specialized-tools	Within-tool differences (exotic).
os-differences	Basic Linux kernel differences.
pthreads	POSIX threads under Linux.
environment-variables	Linux-relevant env. variables.
batch-system	Linux-relevant batch, resource systems.
index	The structural index of keywords.
a	The alphabetical index of keywords.
date	The latest changes to this document.
revisions	The complete revision history.

Alphabetical List of Keywords

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title	The name of this document.
tool-options	Within-tool option, feature differences.
unix-utilities	Standard UNIX tools under Linux.
who	Who to contact for assistance.

Date and Revisions

Revision Date	Keyword Affected	Description of Change
13Jan04	linux-overview	More support sites added.
	lc-utilities	GIVE, TAKE now cross machines.
04Nov03	lc-utilities	More comparisons added.
	pthreads	SLURM replaces RMS, thread aware.
	environment-variables	SLURM env. vars. cross referenced.
	batch-system	Deployment comments updated.
17Sep03	unix-utilities	Mozilla replaces Netscape.
	lc-utilities	Four more status changes.
25Aug03	batch-system	Cross ref to SLURM manual added.
02Jul03	linux-overview	Linux-relevant IBM documents noted.
14May03	netmon	New section on NETMON relevance.
	index	New keyword for new section.
	lc-utilities	No across-machine GIVEs, TAKEs.
	locations	/usr/give present but not used.
22Apr03	lc-utilities	HTAR now on Linux.
	often-used-tools	DF, FTP more differences noted.
	locations	DFS not on any Linux nodes.
11Mar03	linux-overview	Cross ref to CHAOS manual added.
	lc-utilities	PDSH, SUPER added, others revised.
	environment-variables	Details updated and clarified.
	batch-system	Cross ref to CHAOS manual added.
27Jan03	linux-overview	CHAOS deployment noted.
	locations	MKL Intel library pathnames added.
	environment-variables	OMP_NUM_THREADS role added.
	lc-utilities	SFTP added.
	batch-system	New section on TBS, SLURM.
	index	New keyword for new section.
04Dec02	linux-resources	ILX replaces LX cluster on OCF.
	lc-utilities	GIVE, TAKE now under Linux.
	locations	PMATH, SPRNG now in /usr/local/lib.
22Aug02	locations	More on compilers, HDF5 library.
08Jul02	lc-utilities	Two more LC tools added.
	often-used-tools	USERINFO, UINFO compared.
14May02	software	Subdivided, many more details.

	compilers	New subsection on compiling.
	lc-utilities	Availability updated, list expanded.
	pthreads	Linux RMS not thread aware.
	linux-resources	SCF Adelie and Emperor added.
	environment-variables	New section added.
	index	New keywords for new sections.
19Mar02	software	Five more LC tools listed.
12Feb02	software	Three LC-only storage routines listed.
09Jan02	linux-overview	Linux usability study added.
	linux-resources	More OCF LX nodes; o.s. upgrade.
	software	LFT added to list.
06Dec01	software	Four more LC-only tools listed.
19Nov01	entire	First edition of Linux manual.

TRG (13Jan04)

UCRL-WEB-201326

TRG (13Jan04) Contact: lc-hotline@llnl.gov